NISTTech

OPTICAL FREQUENCY COMB-BASED COHERENT LIDAR

Rapid and precise absolute distance measurements at long range

Description

This invention is a laser ranging system that can determine absolute distance to an object with nanometer precision over distances up to 100 kilometers. The novel LIDAR ("light detection and ranging") transmits light through the air and analyzes the weak reflected signal to measure the distance, or range, to the target.

NIST's LIDAR design derives its power to provide absolute distance measurements from combining the best of two different approaches to absolute distance measurements: the time-of-flight, a method for measuring large distances, and interferometry, which is ultraprecise. The LIDAR relies on a pair of optical frequency combs, tools for precisely measuring different colors (or frequencies) of light. The frequency combs used in the LIDAR are based on ultrafast-pulsed fiber lasers. The two combs operate at slightly different numbers of pulses per second. Pulses from one comb are reflected from a moving target and a stationary reference plane. The second comb serves as precise timer to measure the delay between the reflections returning from the target and from the reference plane. A computer calculates the distance between the target and the reference plane by multiplying the time delay by the speed of light.

Applications

- • Automated manufacturing, where many parts need to fit together with tight tolerances
- • Enable multiple satellites to maintain tight spacing and pointing while flying where rapid and precise measurements of absolute distance are critical for maintaining the relative pointing and position of the individual satellites
- • Enable continuous comparisons and feedback of distances to multiple reference points on multiple satellites
- • Maintain the relative pointing and position of individual satellites

Advantages

- • Absolute distance measurements, simultaneously from multiple reflectors, and at low power
- • The system can update measurements to multiple targets simultaneously every 200 microseconds
- • Large ambiguity range of at least 1.5 meters—large enough to check the coarse distance with widely available technologies such as GPS
- • The pulse time-of-flight yields a precision of 3 m with an ambiguity range of 1.5 m in 200 s. Through the optical carrier phase, the precision is improved to better than 5 nm at 60 ms, and through the radio-frequency phase the ambiguity range is extended to 30 km, potentially providing 2 parts in 1013 ranging at long distances

Abstract

A coherent laser radar that uses two coherent femtosecond fiber lasers to perform absolute ranging at long distance. One coherent femtosecond fiber lasers acts as a source and the other as a local oscillator for heterodyne detection of the return signal from a cooperative target. The system simultaneously returns a time-of-flight range measurement for coarse ranging and an interferometric range measurement for fine ranging which is insensitive to spurious reflections that can cause systematic errors. The range is measured with at least 3 μm precision in 200 μs and 5 nm precision in 60 ms over a 1.5 m ambiguity range. This ambiguity range can be extended to 30 km through reversal of signal and LO source roles.

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Citations

1. N. R. Newbury, I. Coddington, and W. C. Swann, "Precision ranging LIDAR using femtosecond fiber lasers", 15th

Coherent Laser Radar Conference, Toulouse, France, 2009.

I. Coddington, W.C. Swann, L. Nenadovic, and N.R. Newbury, "Radid, precise absolute distance measurements at long range," Nature Photonics **3**, 351-356, 2009.

Related Items

- Article: NIST's LIDAR May Offer Peerless Precision in Remote Measurements

References

- U.S. Patent Application; Serial #12/883,491
- Docket: 09-023

Status of Availability

available for licensing

Last Modified: 02/11/2011